STAND-OFF ESTIMATION OF BINARY ASTEROID MASS DISTRIBUTIONS

D.J. Scheeres[1,2] and E.G. Fahnestock[1]

[1]The University of Michigan, Ann Arbor

[2]The University of Colorado, Boulder

Recent investigations of the dynamics and morphology of the binary asteroid system 1999 KW4 have revealed a complex and dynamic system that should be typical of binary asteroids. While investigation of the KW4 system is of intrinsic interest, methods we have developed to understand and characterize this system are also applicable to other NEA binaries with similar morphology. In this presentation we will detail an underlying dynamical theory we have developed and an accompanying procedure which allows one to estimate the mass distribution properties of a binary system without having to fly a spacecraft within the gravitational field of the system. Specifically, we show that in a system such as KW4 there is sufficient information in the dynamical oscillation of its components to estimate the second degree and order gravity field coefficients and moments of inertia of both bodies based on stand-off observations alone. This is significant when compared to the situation for solitary asteroids where the gravity field can only be determined by tracking the motion of a spacecraft perturbed by the higher order gravity coefficients. Also, the moments of inertia cannot be estimated for solitary asteroids, except if the body is in non-uniform rotation. For a binary system with an excitation level similar to KW4's, it is possible to determine the total mass, mass fraction of the system, the J_2 gravity coefficient of the primary, the principal moments of inertia of the secondary, and potentially the principal moments of inertia of the primary if it has a significant equatorial ellipticity. The moments of inertia contain significant information on how the mass is distributed within a body not available from the gravity coefficients alone. The placement of passive probes on the surface of the binary components with radio transmitters can yield significantly improved precision for these estimated quantities. The estimation of these quantities do not require the spacecraft to orbit the system closely, which can reduce a mission's operational costs significantly.